# Fire Growth Modelling at Multiple Scales

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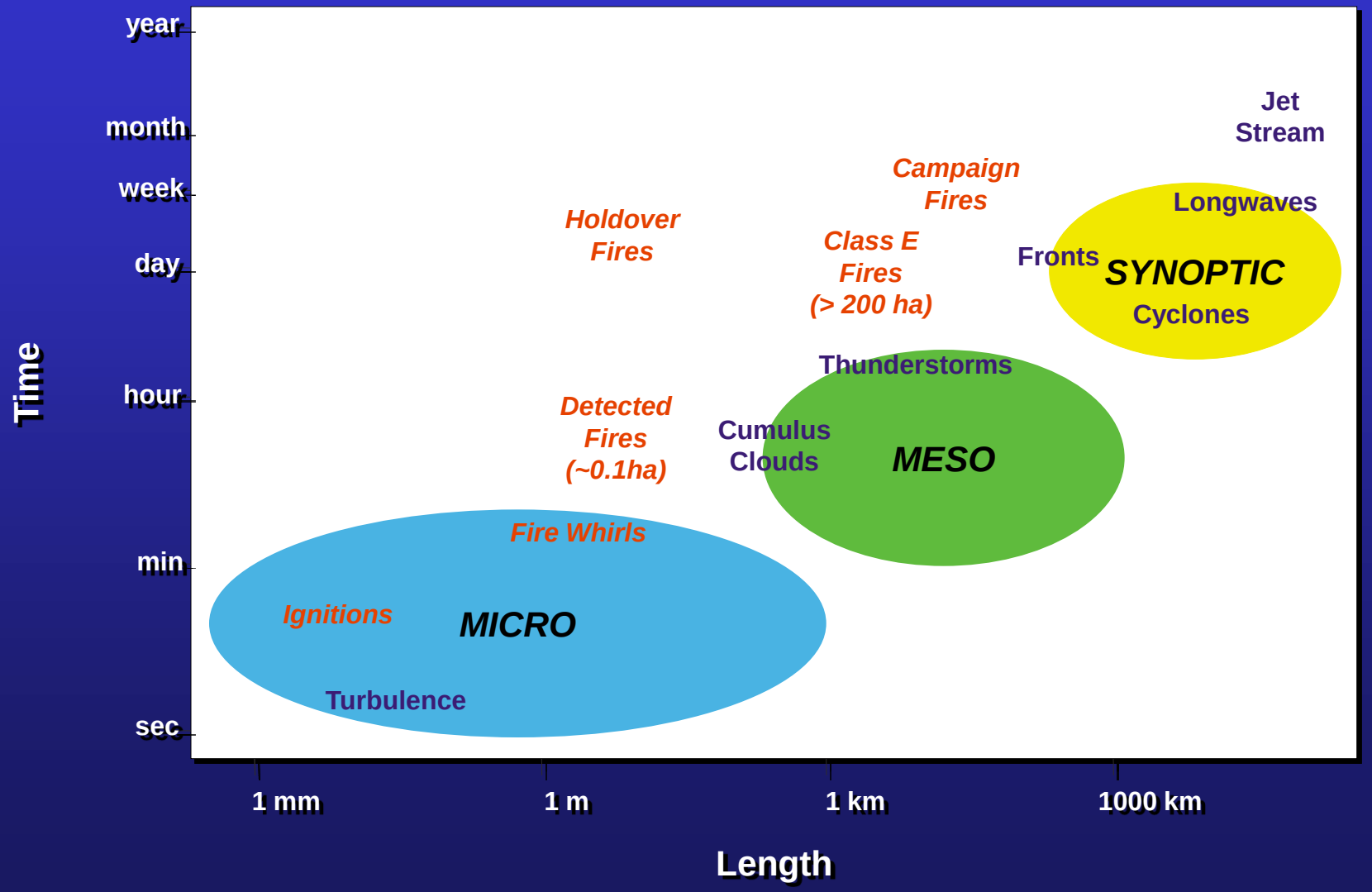
# Fire Growth Modelling at Multiple Scales

## Introduction

Weather and fire activity can be thought of occurring on different time and space scales.

Forecasting at each of these scales has its individual practical and physical limitations.

# Scales


year
month
week
day
hour
min
sec
Time
Jet
Stream
Campaign
Fires
Longwaves
Holdover
Fires
Class E
Fires
(> 200 ha)
Fronts
SYNOPTIC
Cyclones
Thunderstorms
Detected
Fires
(~0.1ha)
Cumulus
Clouds
MESO
Fire Whirls
Ignitions
MICRO
Turbulence
1 mm
1 m
1 km
1000 km
Length

# Fire Growth Modelling at Multiple Scales

## Introduction

Fire growth modelling can fall into three scales depending on weather forecasting ability:

Short-range: 1-2 days

Medium-range: 3-7 days

Long-range: 8+ days

# Fire Growth Modelling at Multiple Scales

## Introduction

As the run time increases, the model becomes less deterministic and more probabilistic.

Short-range | Medium-range | Long-range

*deterministic*
*weather-based*
*detailed*

*probabilistic*
*climate -based*
*generalized*

# Fire Growth Modelling at Multiple Scales

## The Models

This presentation shows a fire growth modelling system designed to run consecutively over three time scales.

The models are designed so that they may be run in sequence, with the results of one model initializing the subsequent model run.

# *Short-range Fire Growth*

# Fire Growth Modelling at Multiple Scales

## Short-range Fire Growth

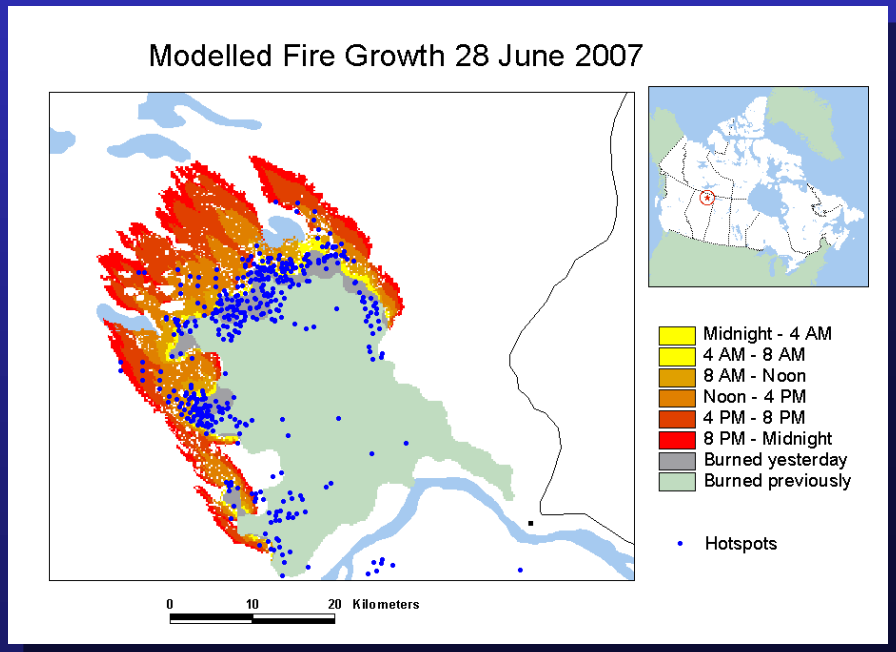
USFS **Farsite** and the Canadian **Prometheus**



are examples of operational, deterministic, short-range fire growth models.

# Fire Growth Modelling at Multiple Scales

## Short-range Fire Growth



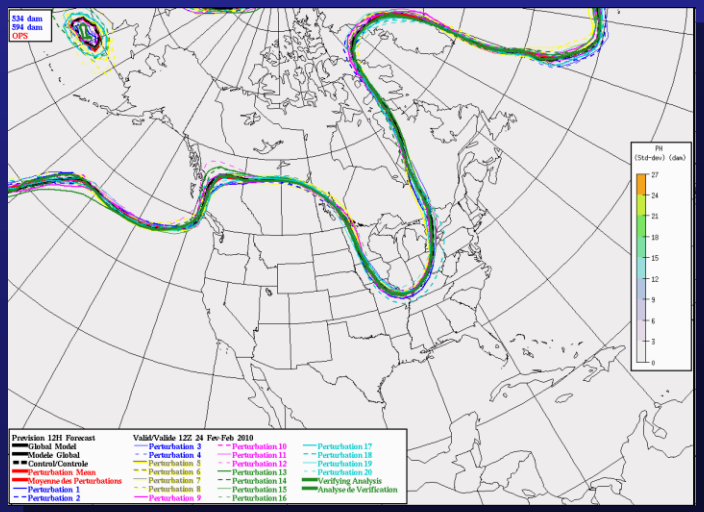

MODIS hotspots and numerical weather predictions (NWP) can be used to create short-range predictions for the next 24 to 48 hours.

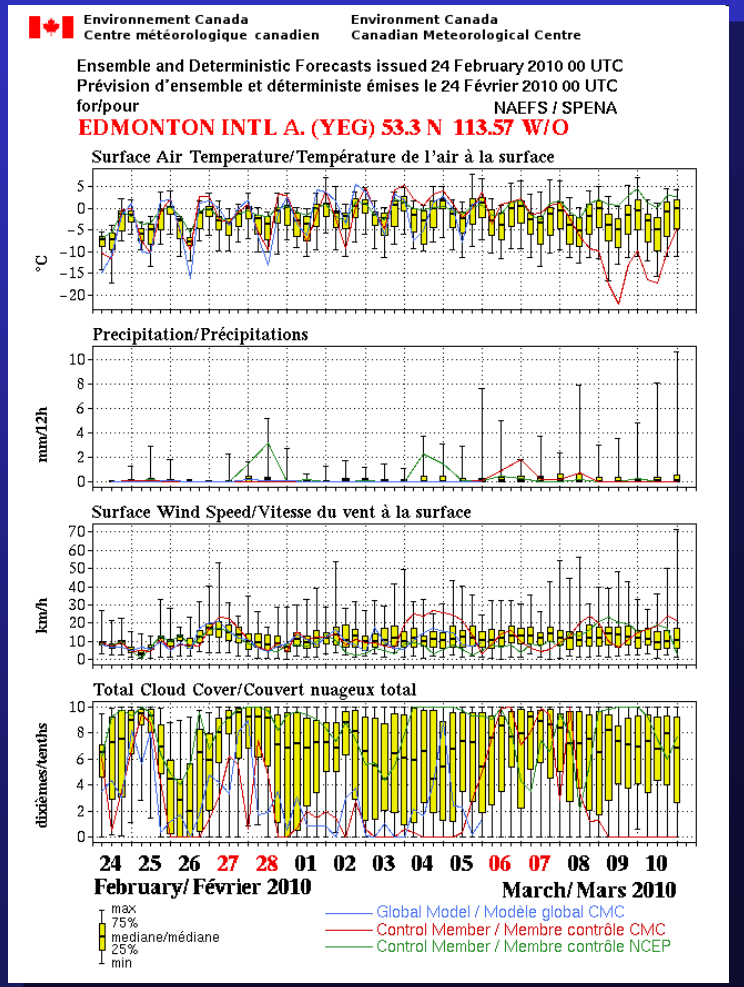
# *Medium-range Fire Growth*

# Fire Growth Modelling at Multiple Scales

## Medium-range Fire Growth

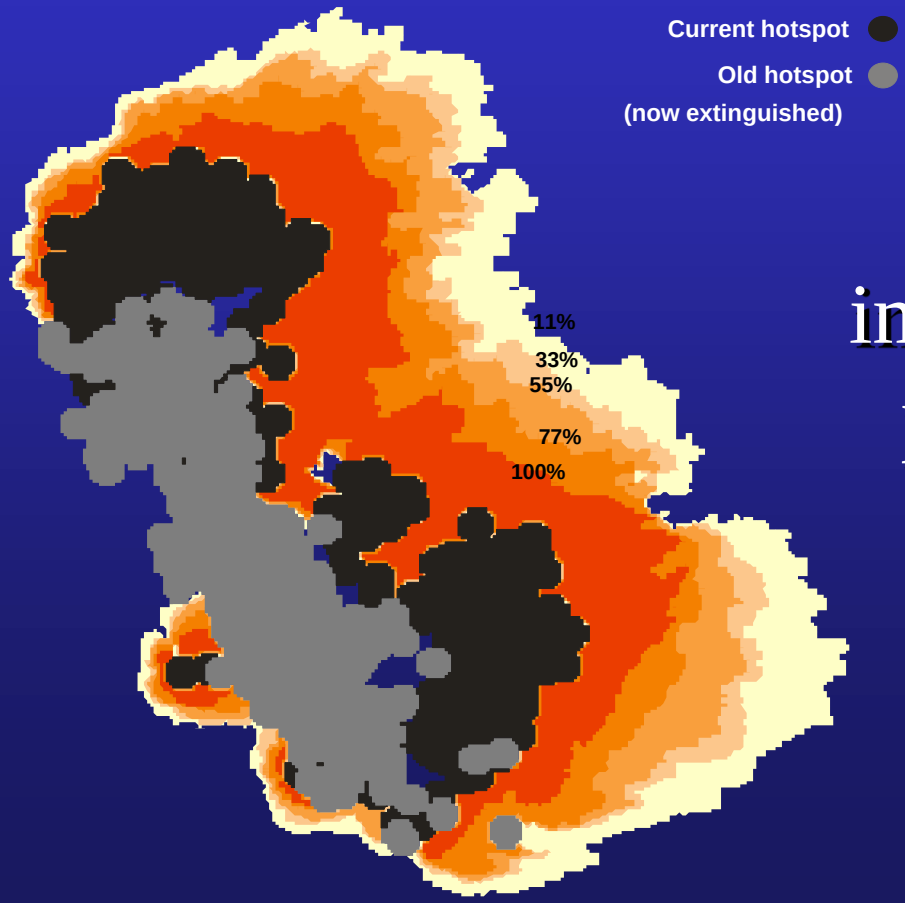
Currently we are examining ensemble weather products for use in medium-range fire growth predictions.





# Fire Growth Modelling at Multiple Scales

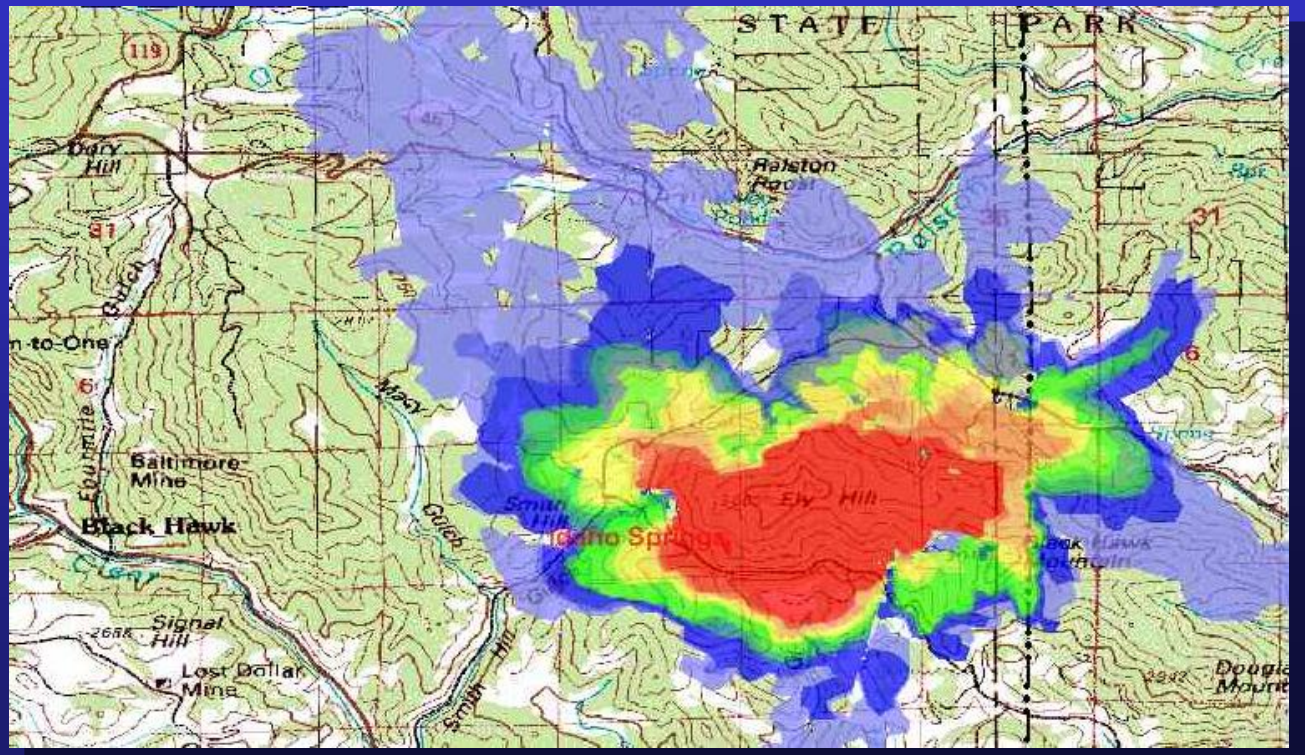
## Medium-range Fire Growth




Case studies show an improvement in fire growth predictions when using an ensemble approach.

# Fire Growth Modelling at Multiple Scales

# Medium-range Fire Growth




The WFDSS - **FSPro** – Fire Spread Probability Model.

# *Long-range Fire Growth*

## Fire Growth Modelling at Multiple Scales

# Long-range Fire Growth

The **Probabilistic Fire Analysis System** (**PFAS**) is a long-range fire growth model based upon climatology.

Such models are probabilistic and thus output is represented as probable fire extents.

## Fire Growth Modelling at Multiple Scales

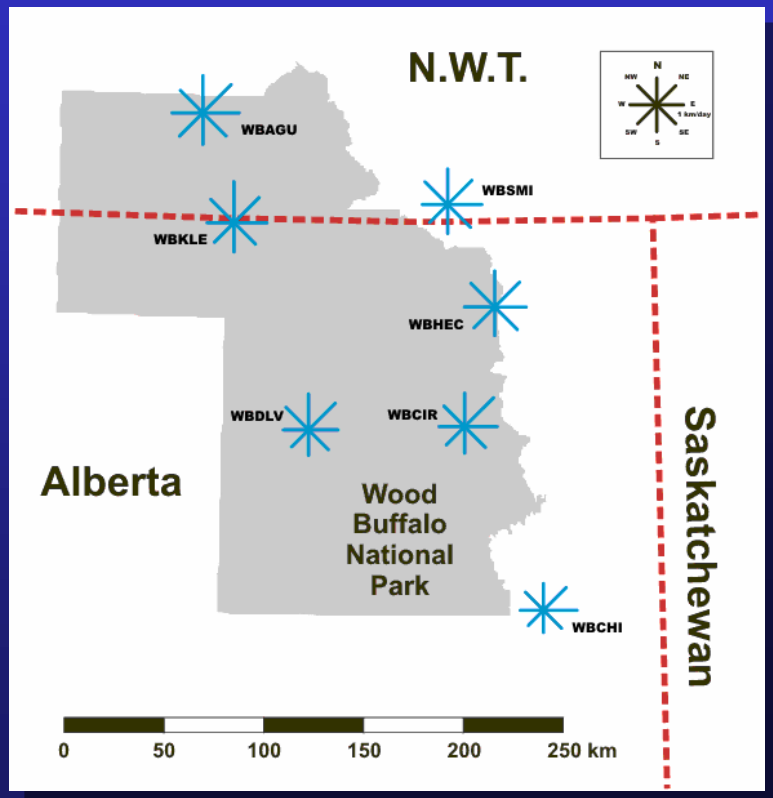
# Long-range Fire Growth

Long term fire growth from one location to another within a given time period is the probability that the fire will spread across the distance before a fire-stopping rain event occurs.

$$p(t) = p_{spread}(t) \cdot P_{survival}(t)$$

# Fire Growth Modelling at Multiple Scales

## Long-range Fire Growth



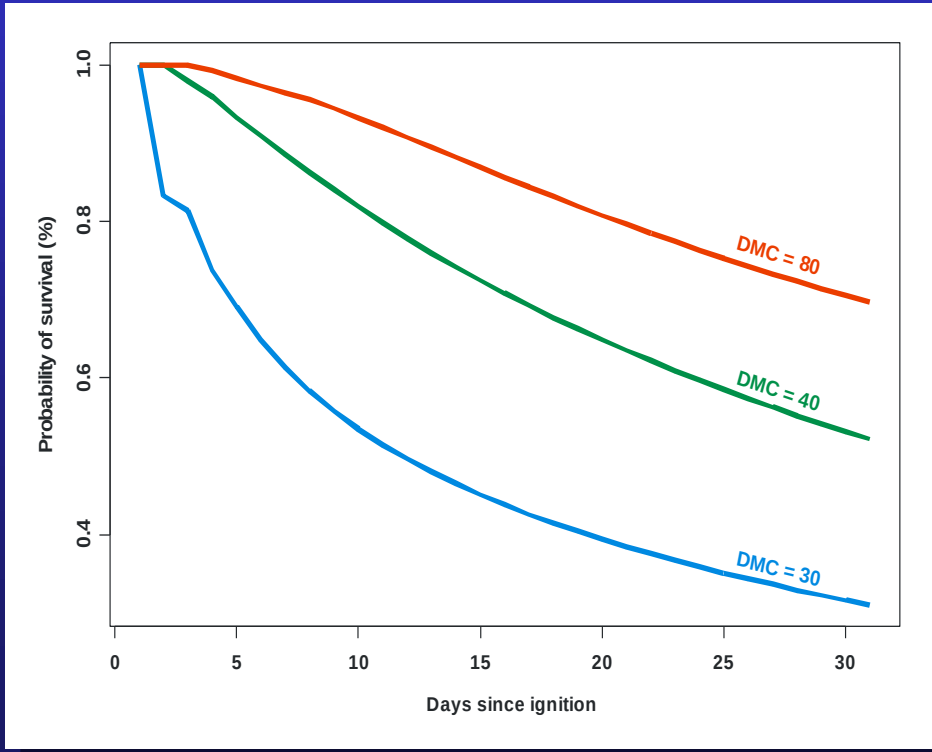

The probability of spread is based on exponential distributions.

These are similar to wind roses but for the rate of spread for each fuel type.

Mean rates of spread in C2 fuel type for August

# Fire Growth Modelling at Multiple Scales

## Long-range Fire Growth



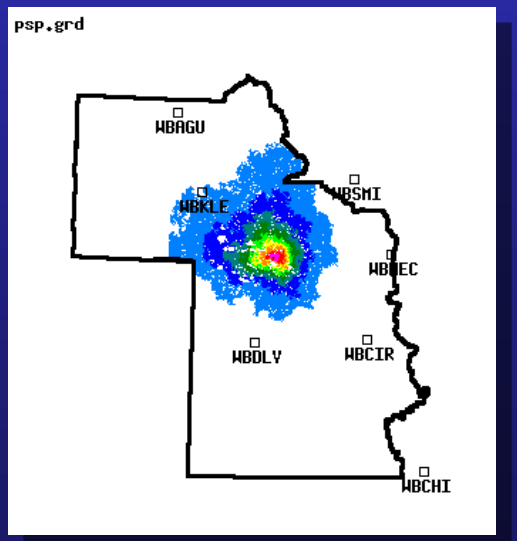

Probability of survival is solved using Markov Chains and DMC.

As time progresses, the probability of survival drops to zero.

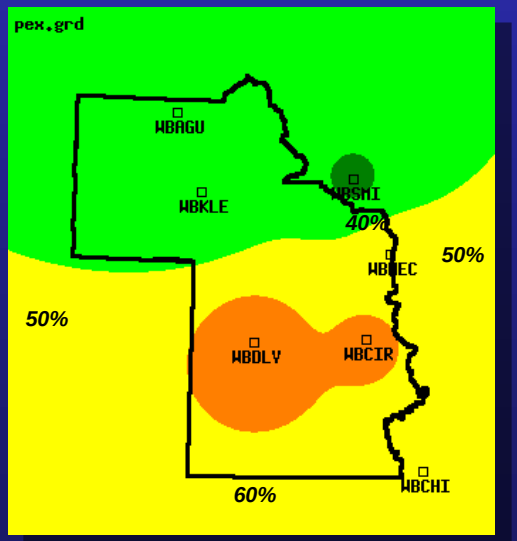
# Fire Growth Modelling at Multiple Scales

## Long-range Fire Growth

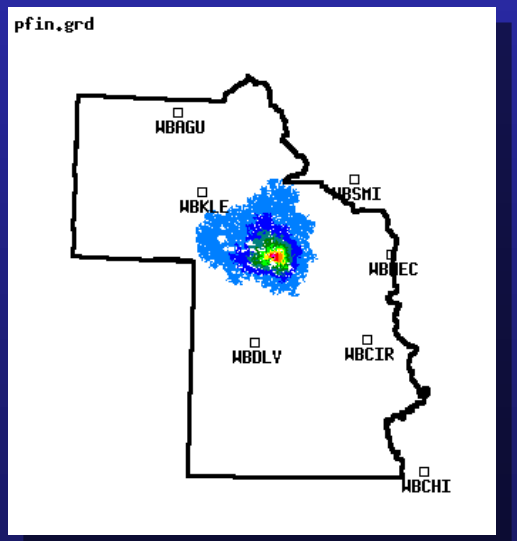
The model calculates the probabilities of spread and of survival and combines them spatially to produce a probable fire extents map.




*Spread*




*Extinction*
*(1-Survival)*

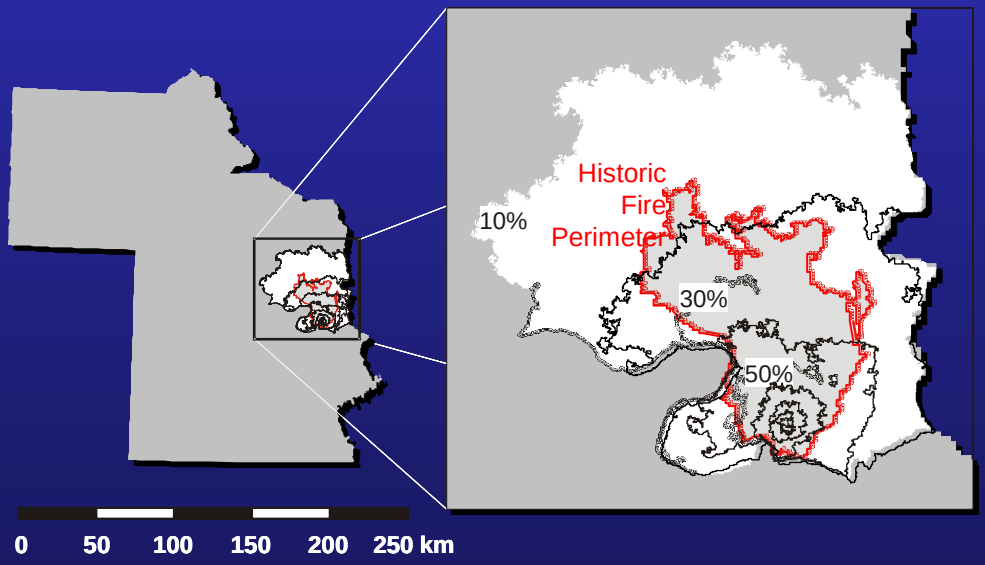



*Extents*

# Fire Growth Modelling at Multiple Scales

# Long-range Fire Growth

Comparisons with historical fires indicate the model produces realistic results

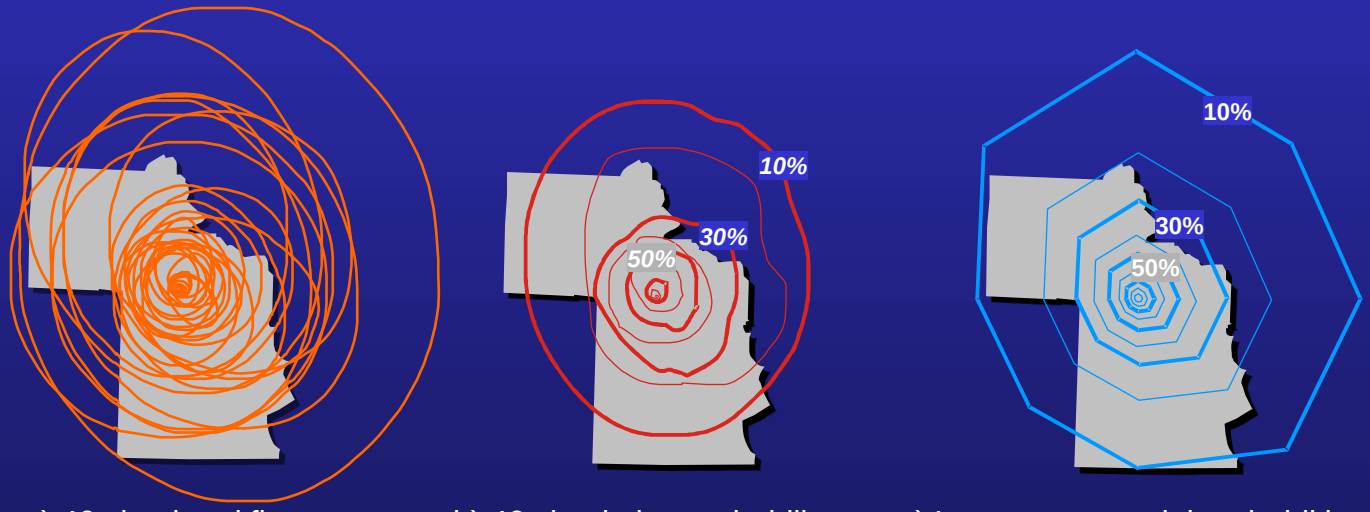



*…but is difficult to validate this way.*

# Fire Growth Modelling at Multiple Scales

# Long-range Fire Growth

The long-range model predictions were compared with distributions of fire perimeters predicted by repeated simulations using the hourly-based, deterministic fire-growth model.




a) 40 simulated fires

b) 40 simulation probability

c) Long-range model probabiltiy

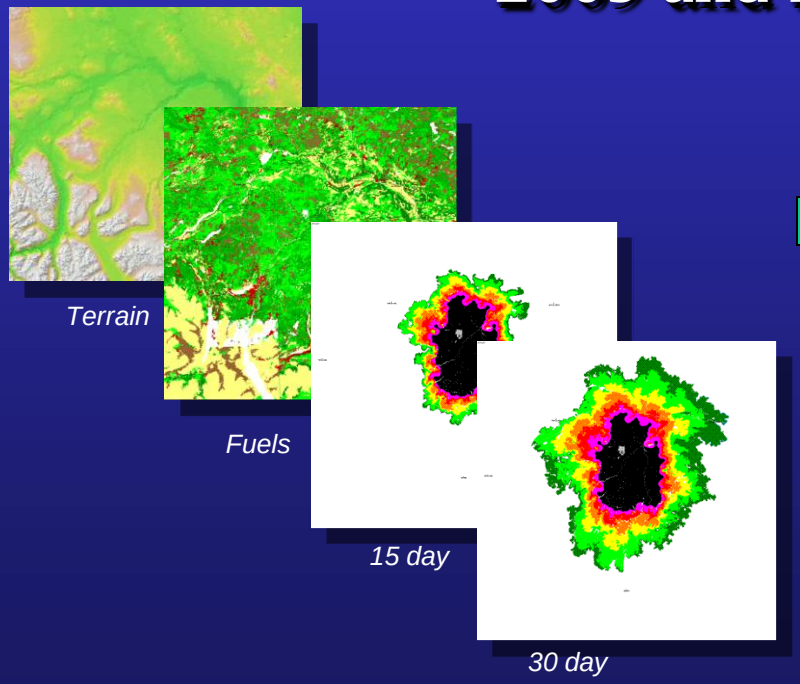
The study showed a close agreement between the long-range model and the deterministic model.

# *2009 & 2010 Fire Seasons in BC*

# Fire Growth Modelling at Multiple Scales

# Long-range Fire Growth

The long-range model PFAS was used in BC during the 2009 and 2010 fire seasons.




**Fire Growth Projection (Prescribed Fire Analysis System)**

Current fire perimeter (approx 76 000 ha)

15 day area at risk (approx 180 000 ha) (50 % probability)

30 day area at risk (approx 317 000 ha) (50 % probability)

Predictions were used to assess modified response decisions.

## Fire Growth Modelling at Multiple Scales

# Long-range Fire Growth

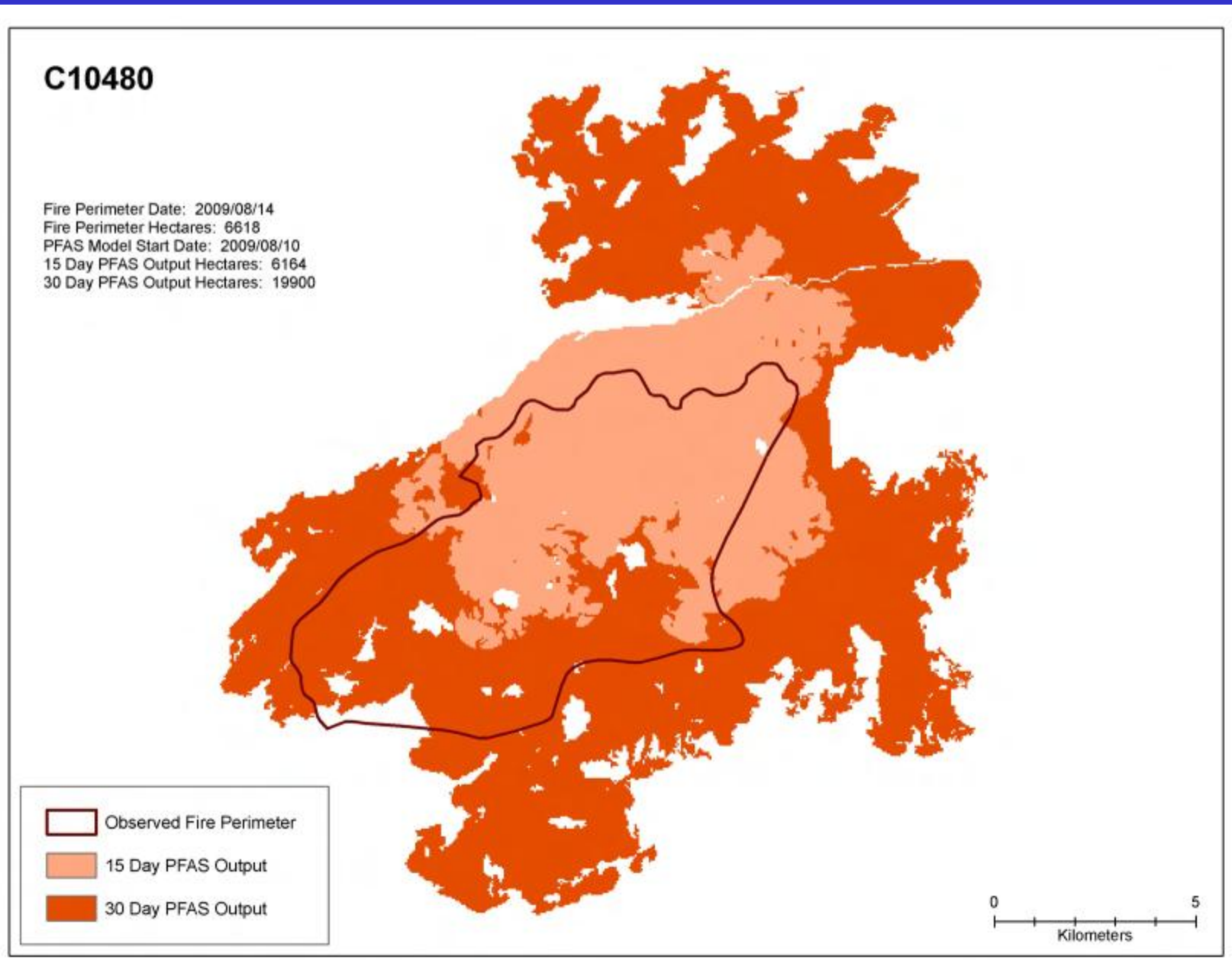
In 2009, PFAS predictions were used to assess modified response decisions made on 37 fires.

In 2010, this was done on 10-12 fires.

In all cases, PFAS was used to supplement the decision support decision made by fire suppression officers (*reassurances*).

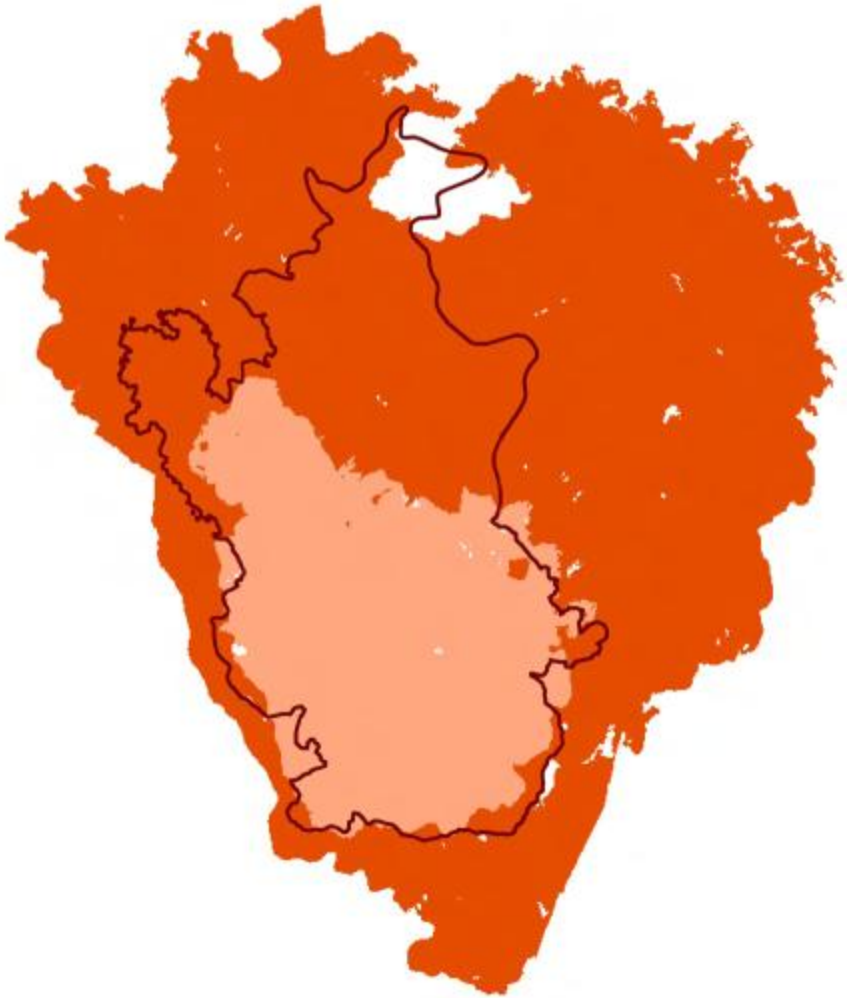
In a few cases, the predictions triggered a reassessment of the suppression response plan.

# *The Good*


C10480
Fire Perimeter Date: 2009/08/14
Fire Perimeter Hectares: 6618
PFAS Model Start Date: 2009/08/10
15 Day PFAS Output Hectares: 6164
30 Day PFAS Output Hectares: 19900
Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output
0
5
Kilometers

# C40429

Fire Perimter Date: 2009/09/25
Fire Perimeter Hectares: 20610
PFAS Model Start Date: 2009/08/10
15 Day PFAS Output Hectares: 12300
30 Day PFAS Output Hectares: 53215

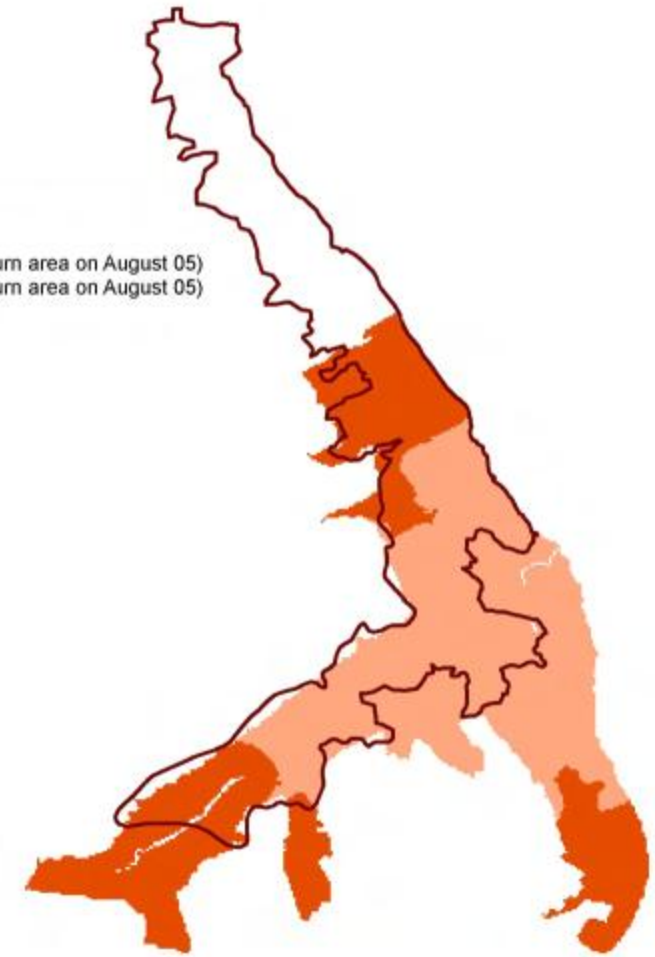


Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

0 5
Kilometers

# C50400

Fire Perimter Date: 2009/08/30
Fire Perimeter Hectares: 4170
PFAS Model Start Date: 2009/08/13
15 Day PFAS Output Hectares: 3071 (in addition to total burn area on August 05)
30 Day PFAS Output Hectares: 5454 (in addition to total burn area on August 05)



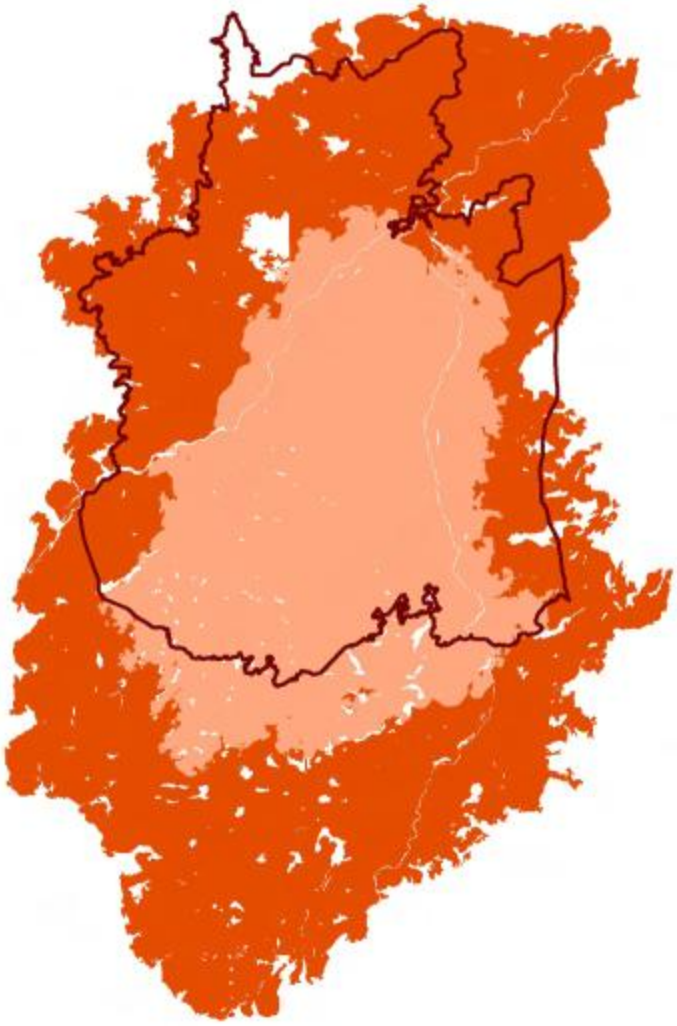
Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* Fuel layer was retyped for some areas

0 5
Kilometers

# C50418

Fire Perimter Date: 2009/09/26
Fire Perimeter Hectares: 67743
PFAS Model Start Date: 2009/08/10
15 Day PFAS Output Hectares: 45303
30 Day PFAS Output Hectares: 128433



Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

0 5
Kilometers

# G50283

Fire Perimter Date: 2009/10/14
Fire Perimeter Hectares: 441
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 590
30 Day PFAS Output Hectares: *

Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output

0 5
Kilometers

# G50294

Fire Perimter Date: 2009/10/14
Fire Perimeter Hectares: 448
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 135
30 Day PFAS Output Hectares: *

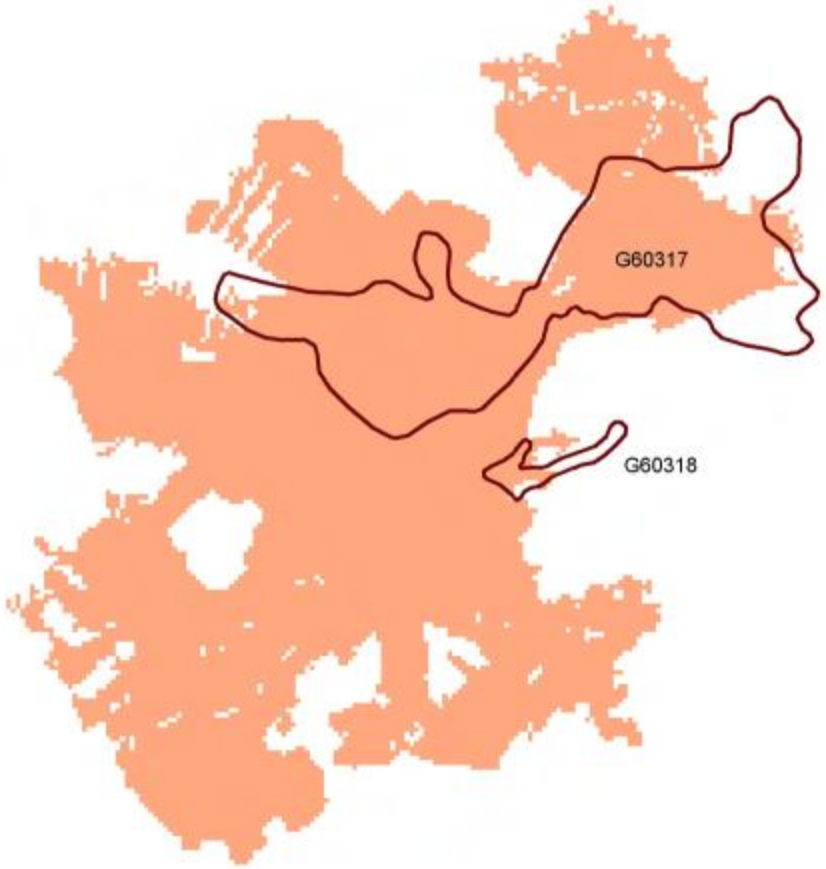
Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output

0 5
Kilometers

# G60317

Fire Perimter Date: 2009/09/22
Fire Perimeter Hectares: 794
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 3414
30 Day PFAS Output Hectares: *



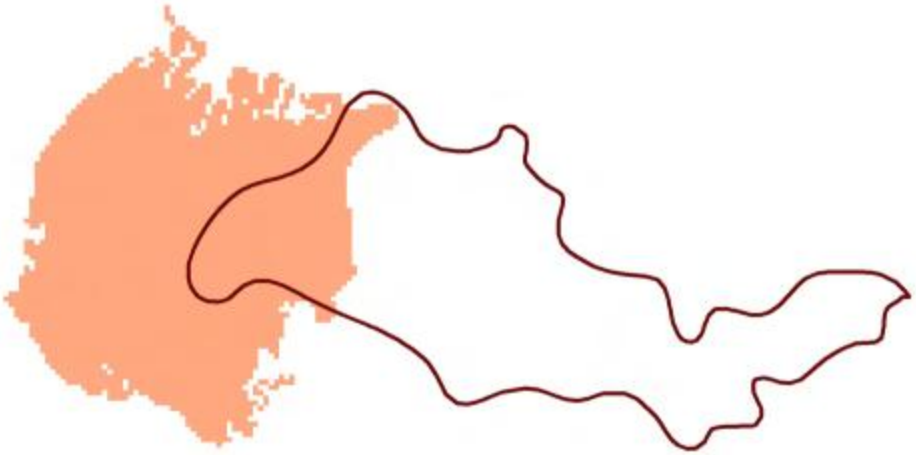

Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output

0 5
Kilometers

# G50278

Fire Perimter Date: 2009/10/14
Fire Perimeter Hectares: 909
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 876
30 Day PFAS Output Hectares: *



Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

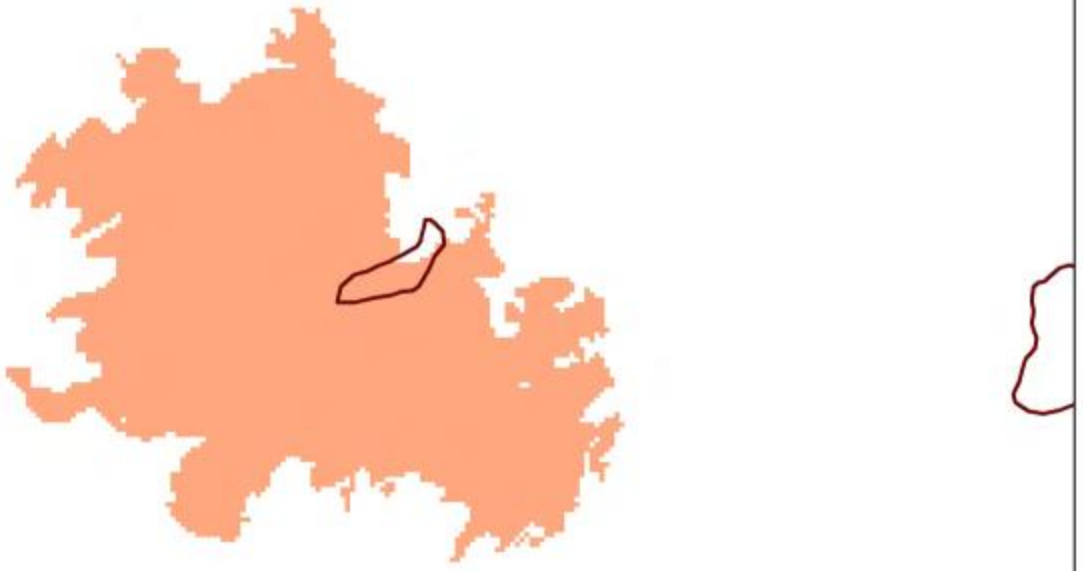
* 30 Day Output same as 15 Day Output

0 5
Kilometers

# *The Bad*

# G60321

Fire Perimter Date: 2009/09/22
Fire Perimeter Hectares: 35
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 1805
30 Day PFAS Output Hectares: *



Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output

0 5
Kilometers

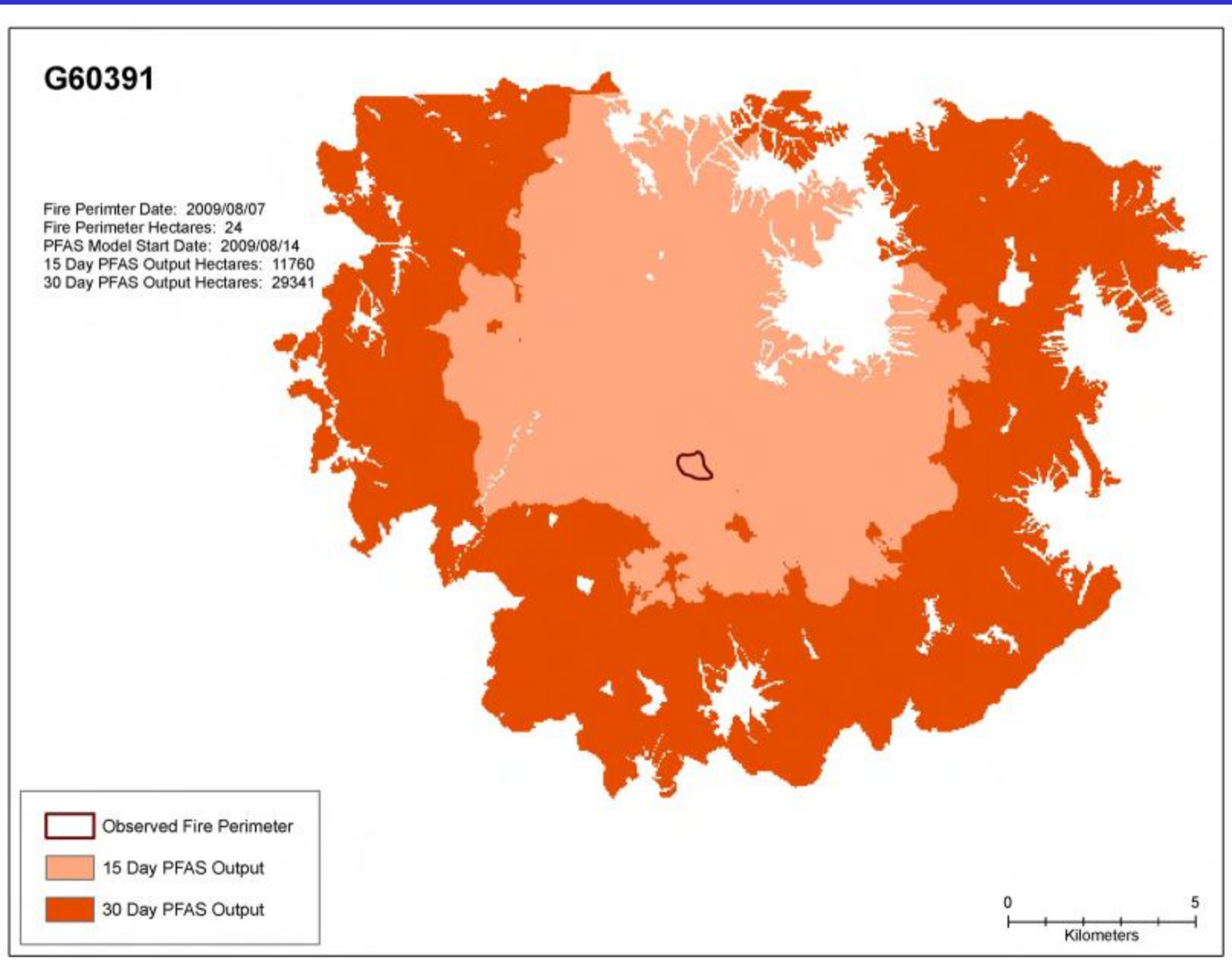
# G60350

Fire Perimter Date: 2009/09/23
Fire Perimeter Hectares: 28
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 1812
30 Day PFAS Output Hectares: *

Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

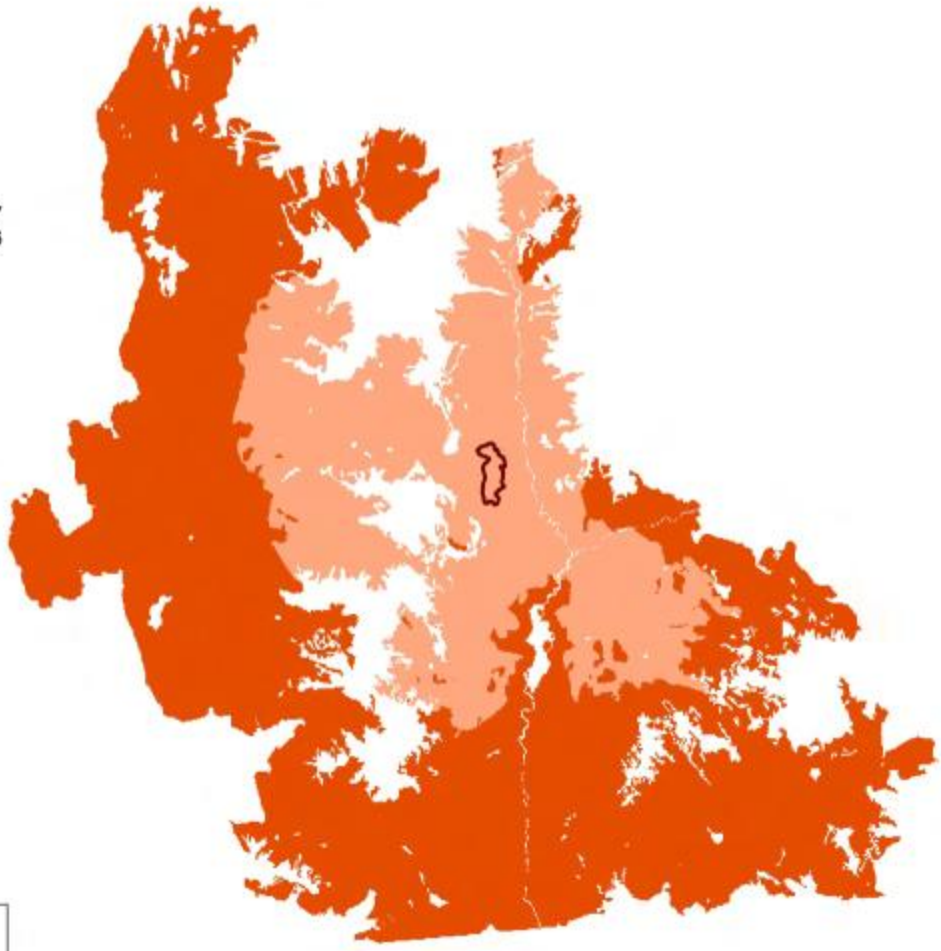
* 30 Day Output same as 15 Day Output

0 5
Kilometers


G60391
Fire Perimter Date: 2009/08/07
Fire Perimeter Hectares: 24
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 11760
30 Day PFAS Output Hectares: 29341
Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output
0
5
Kilometers

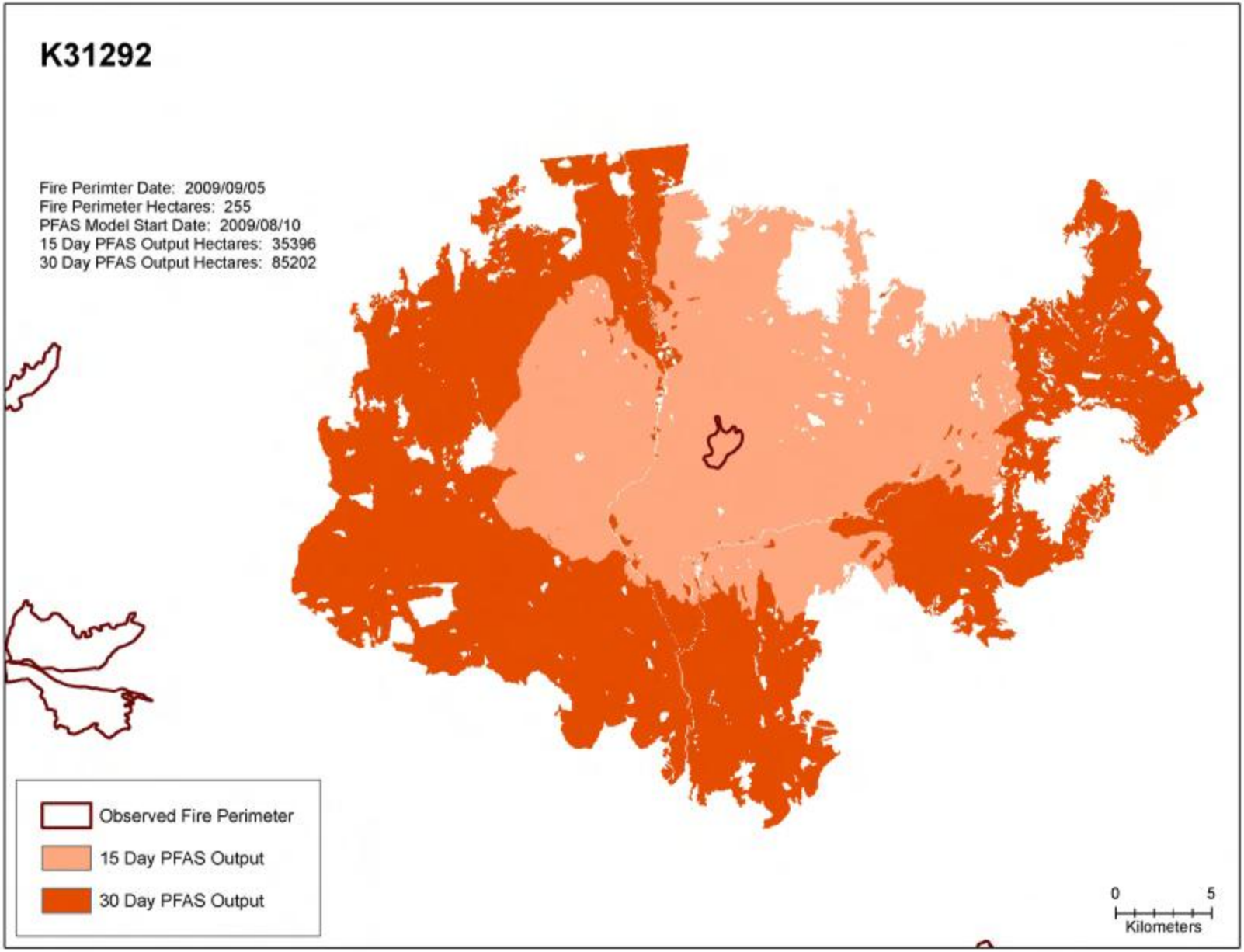
# K31094

Fire Perimter Date: 2009/08/31
Fire Perimeter Hectares: 136
PFAS Model Start Date: 2009/08/10
15 Day PFAS Output Hectares: 15357
30 Day PFAS Output Hectares: 51296



Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

0 5
Kilometers


K31292
Fire Perimter Date: 2009/09/05
Fire Perimeter Hectares: 255
PFAS Model Start Date: 2009/08/10
15 Day PFAS Output Hectares: 35396
30 Day PFAS Output Hectares: 85202
Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output
0
5
Kilometers

# *The Ugly*

# G60318

Fire Perimter Date: 2009/09/22
Fire Perimeter Hectares: 33
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 1700
30 Day PFAS Output Hectares: *

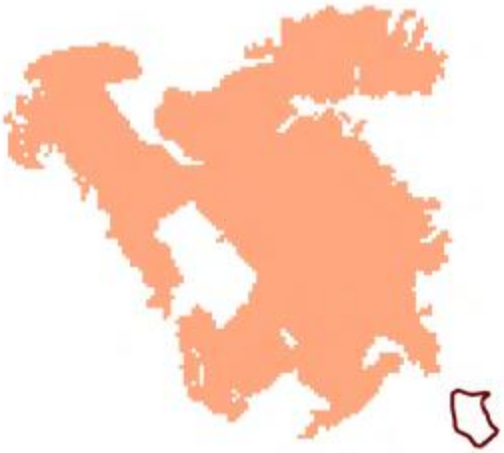

Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output

0 5
Kilometers

# G60351

Fire Perimter Date: 2009/09/22
Fire Perimeter Hectares: 24
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 1477
30 Day PFAS Output Hectares: *



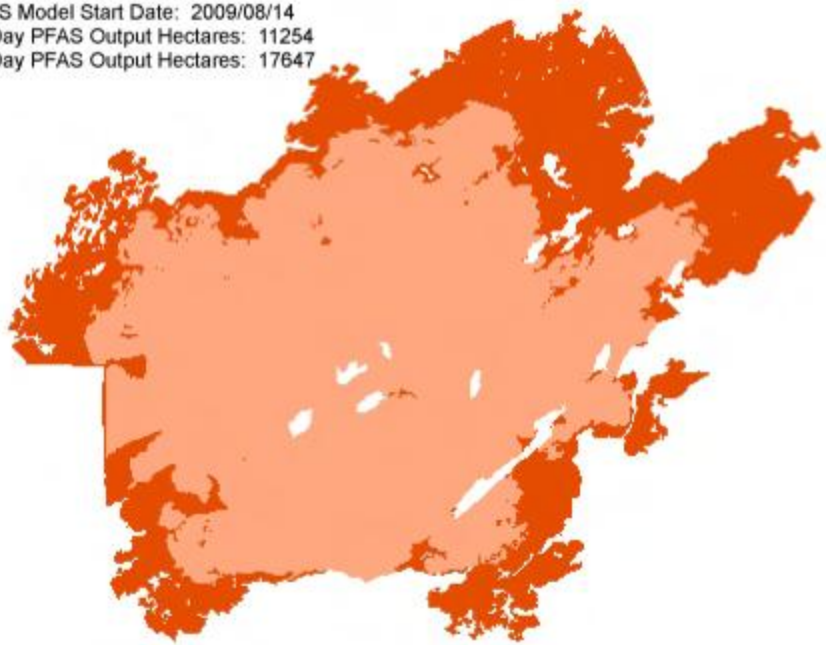
Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output

0 5
Kilometers

# G40306

Fire Perimter Date: 2009/10/14
Fire Perimeter Hectares: 909
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 11254
30 Day PFAS Output Hectares: 17647

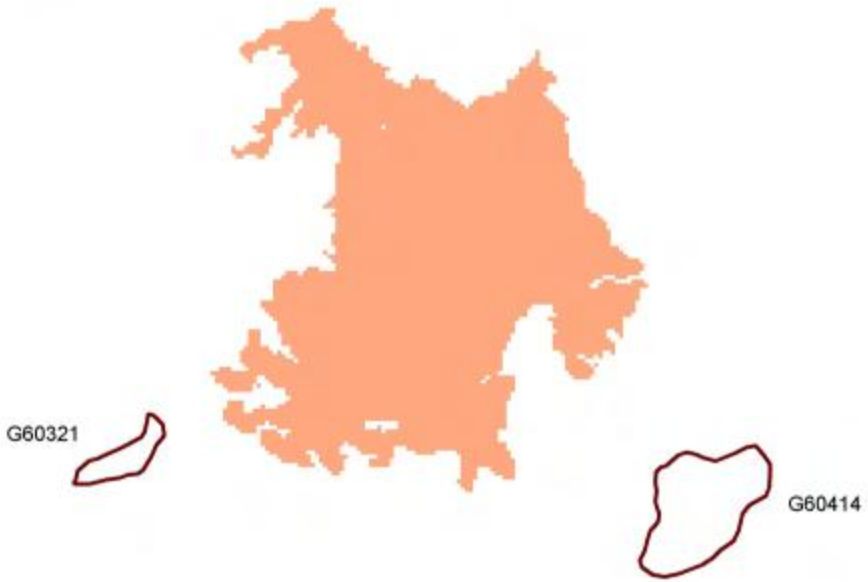


Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

0 5
Kilometers

# G60414

Fire Perimter Date: 2009/09/22
Fire Perimeter Hectares: 155
PFAS Model Start Date: 2009/08/14
15 Day PFAS Output Hectares: 1605
30 Day PFAS Output Hectares: *



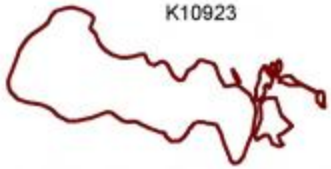

Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output

0 5
Kilometers

# K10923

Fire Perimter Date: 2009/11/05
Fire Perimeter Hectares: 766
PFAS Model Start Date: 2009/08/17
15 Day PFAS Output Hectares: 496
30 Day PFAS Output Hectares: *



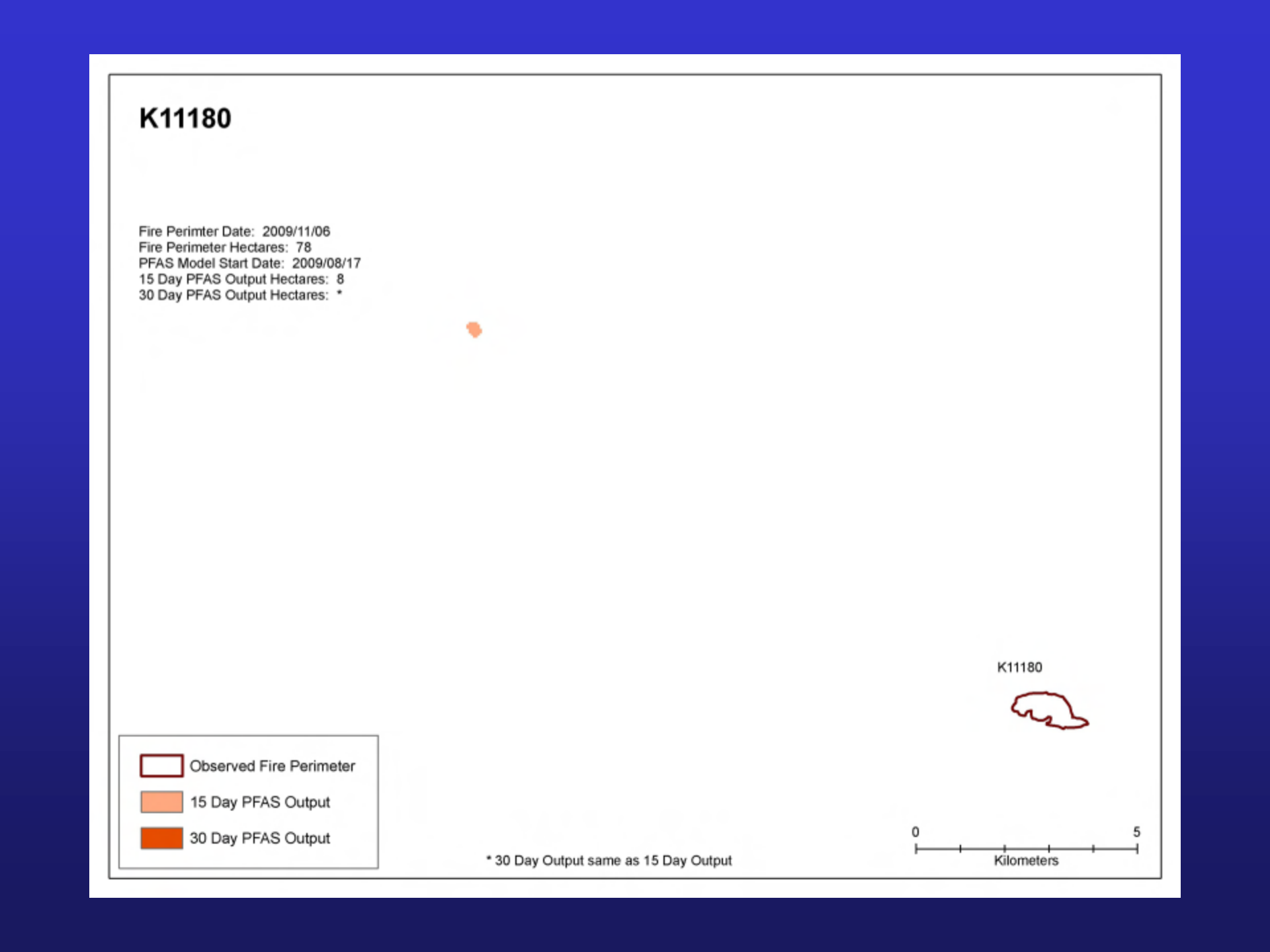

Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output

0 5
Kilometers

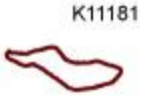
# K11180

Fire Perimter Date: 2009/11/06
Fire Perimeter Hectares: 78
PFAS Model Start Date: 2009/08/17
15 Day PFAS Output Hectares: 8
30 Day PFAS Output Hectares: *



# K11181

Fire Perimter Date: 2009/07/31
Fire Perimeter Hectares: 98
PFAS Model Start Date: 2009/08/17
15 Day PFAS Output Hectares: 787
30 Day PFAS Output Hectares: *




Observed Fire Perimeter
15 Day PFAS Output
30 Day PFAS Output

* 30 Day Output same as 15 Day Output
** EOSD was used to estimate missing fuel data

0 5
Kilometers

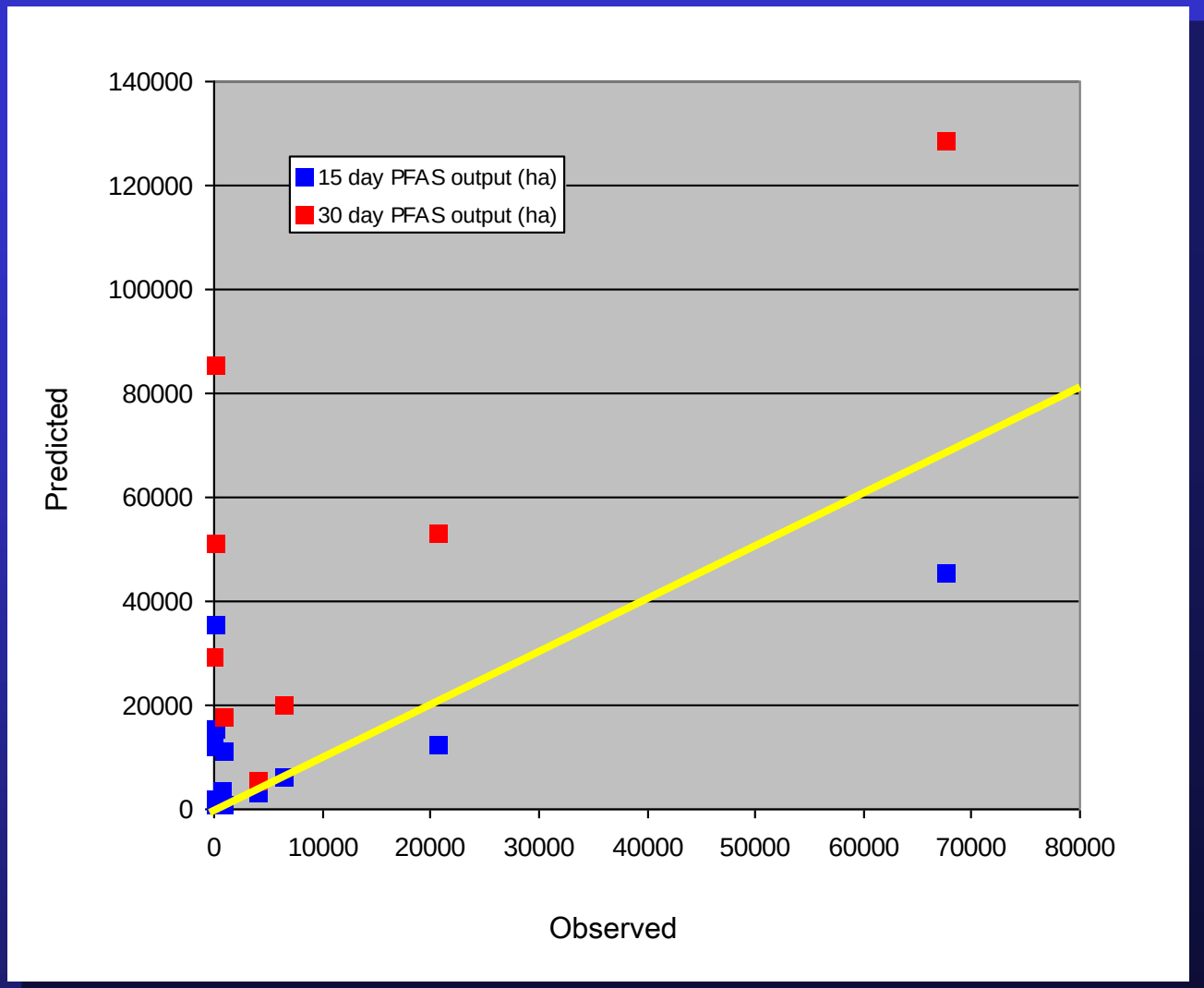
## Fire Growth Modelling at Multiple Scales

# Long-range Fire Growth

***The Good*** may represent fires that were allowed to grow naturally where no processes interfered with immediate spread.

***The Bad*** may represent the fires that were actioned or had some natural process limit their spread.

***The Ugly*** likely corresponds to poor fire information.




The scatter plot shows that for large fires ( ***the Good*** ), the long-range model produced realistic fire sizes.

# Fire Growth Modelling at Multiple Scales

## Conclusions

As forest protection agencies re-evaluate the role of fire in the landscape and its ecological benefits, as they face the prospect of excessive fuel build up resulting from years of fire exclusion policies, and as they contend with fiscal constraints, these agencies must start looking at possible fire growth over extended periods.

The methods presented through these models may serve as a foundation for such evaluation.